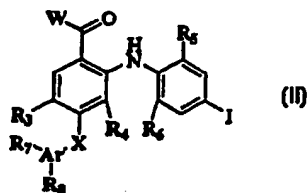




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(54) Title: 4-ARYLAMINO, 4-ARYLOXY, AND 4-ARYLTHIO DIARYLAMINES AND DERIVATIVES THEREOF AS SELECTIVE MEK INHIBITORS



(57) Abstract

The invention provides compounds of formula (II), wherein Ar, R₃, R₄, R₅, R₆, R₇, R₈ and W have the meanings given in the description. They are selective MEK inhibitors.

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4-ARYLAMINO, 4-ARYLOXY, AND 4-ARYLTHIO DIARYLAMINES AND DERIVATIVES THEREOF AS
SELECTIVE MEK INHIBITORS

This invention relates to 4-arylamino, 4-aryloxy, and 4-arylthio
diarylamines and derivatives thereof.

5

BACKGROUND

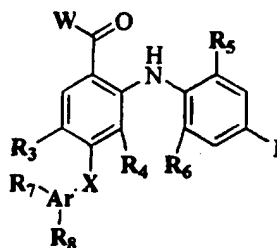
MEK enzymes are dual specificity kinases involved in, for example,
immunomodulation, inflammation, and proliferative diseases such as cancer and
restenosis.

- 10 Proliferative diseases are caused by a defect in the intracellular signaling
system, or the signal transduction mechanism of certain proteins. Defects
include a change either in the intrinsic activity or in the cellular concentration of
one or more signaling proteins in the signaling cascade. The cell may produce a
growth factor that binds to its own receptors, resulting in an autocrine loop, which
15 continually stimulates proliferation. Mutations or overexpression of intracellular
signaling proteins can lead to spurious mitogenic signals within the cell. Some of
the most common mutations occur in genes encoding the protein known as Ras,
a G-protein that is activated when bound to GTP, and inactivated when bound to
GDP. The above-mentioned growth factor receptors, and many other mitogenic
20 receptors, when activated, lead to Ras being converted from the GDP-bound
state to the GTP-bound state. This signal is an absolute prerequisite for
proliferation in most cell types. Defects in this signaling system, especially in the
deactivation of the Ras-GTP complex, are common in cancers, and lead to the
signaling cascade below Ras being chronically activated.
- 25 Activated Ras leads in turn to the activation of a cascade of serine/threonine
kinases. One of the groups of kinases known to require an active Ras-GTP for its
own activation is the Raf family. These in turn activate MEK (e.g., MEK₁ and
MEK₂) which then activates MAP kinase, ERK (ERK₁ and ERK₂). Activation of
MAP kinase by mitogens appears to be essential for proliferation; constitutive
30 activation of this kinase is sufficient to induce cellular transformation. Blockade of
downstream Ras signaling, for example by use of a dominant negative Raf-
1 protein, can completely inhibit mitogenesis, whether induced from cell surface

receptors or from oncogenic Ras mutants. Although Ras is not itself a protein kinase, it participates in the activation of Raf and other kinases, most likely through a phosphorylation mechanism. Once activated, Raf and other kinases phosphorylate MEK on two closely adjacent serine residues, S²¹⁸ and S²²² in the case of MEK-1, which are the prerequisite for activation of MEK as a kinase. MEK in turn phosphorylates MAP kinase on both a tyrosine, Y¹⁸⁵, and a threonine residue, T¹⁸³, separated by a single amino acid. This double phosphorylation activates MAP kinase at least 100-fold. Activated MAP kinase can then catalyze the phosphorylation of a large number of proteins, including several transcription factors and other kinases. Many of these MAP kinase phosphorylations are mitogenically activating for the target protein, such as a kinase, a transcription factor, or another cellular protein. In addition to Raf-1 and MEKK, other kinases activate MEK, and MEK itself appears to be a signal integrating kinase. Current understanding is that MEK is highly specific for the phosphorylation of MAP kinase. In fact, no substrate for MEK other than the MAP kinase, ERK, has been demonstrated to date and MEK does not phosphorylate peptides based on the MAP kinase phosphorylation sequence, or even phosphorylate denatured MAP kinase. MEK also appears to associate strongly with MAP kinase prior to phosphorylating it, suggesting that phosphorylation of MAP kinase by MEK may require a prior strong interaction between the two proteins. Both this requirement and the unusual specificity of MEK are suggestive that it may have enough difference in its mechanism of action to other protein kinases that selective inhibitors of MEK, possibly operating through allosteric mechanisms rather than through the usual blockade of the ATP binding site, may be found.

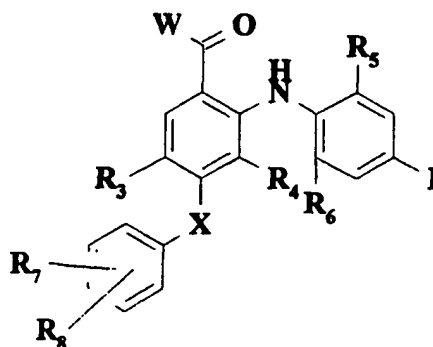
SUMMARY

The invention features compounds of formulae (II) below, such as formula(I):



5

(II)



10

(I)

- In formulae (I) and (II), W is OR₁, NR₂OR₁, NR_AR_B, NR₂NR_AR_B, or NR₂(CH₂)₂₋₄NR_AR_B. R₁ is H, C₁₋₈ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, phenyl, (phenyl)C₁₋₄ alkyl, (phenyl)C₃₋₄ alkenyl, (phenyl)C₃₋₄ alkynyl, (C₃₋₈ cycloalkyl)-C₁₋₄ alkyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkenyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkynyl, C₃₋₈ heterocyclic radical, (C₃₋₈ heterocyclic radical)C₁₋₄ alkyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkenyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkynyl, or (CH₂)₂₋₄NR_AR_B. R₂

3

is H, phenyl, C₁₋₄ alkyl, C₃₋₄ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, or (C₃₋₈ cycloalkyl)C₁₋₄ alkyl. R_A is H, C₁₋₆ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, phenyl, (C₃₋₈ cycloalkyl)C₁₋₄ alkyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkenyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkynyl, C₃₋₈ heterocyclic radical, (C₃₋₈ heterocyclic radical)C₁₋₄ alkyl, (aminosulfonyl)phenyl, [(aminosulfonyl)phenyl]C₁₋₄ alkyl, (aminosulfonyl)C₁₋₆ alkyl, (aminosulfonyl)C₃₋₆ cycloalkyl, or [(aminosulfonyl)C₃₋₆ cycloalkyl]C₁₋₄ alkyl. R_B is H, C₁₋₈ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, or C₆₋₈ aryl. R₃ is halo, NO₂, SO₂NR_I(CH₂)₂₋₄NR_ER_F, SO₂NR_IR_K or (CO)T. T is C₁₋₈ alkyl, C₃₋₈ cycloalkyl, (NR_ER_F)C₁₋₄ alkyl, OR_F, NR_I(CH₂)₂₋₄NR_ER_F, or NR_ER_F. R₄ is H or F; R₅ is H, methyl, halo, or NO₂; and R₆ is H, methyl, halo, or NO₂. In formula (II), Ar is phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl. Each of R₇ and R₈ is independently selected from H, halo, C₁₋₄ alkyl, SO₂NR_J(CH₂)₂₋₄NR_GR_H, (CO)(CH₂)₂₋₄NR_GR_H, (CO)NR_J(CH₂)₂₋₄NR_GR_H, (CO)O(CH₂)₂₋₄NR_GR_H, SO₂NR_GR_H, and (CO)NR_GR_H. However, where Ar is a pyridyl, each of R₇ and R₈ is H. Each of R_C, R_D, R_E, R_F, R_G, and R_H is independently selected from H, C₁₋₄ alkyl, C₃₋₄ alkenyl, C₃₋₄ alkynyl, C₃₋₆ cycloalkyl, and phenyl. Each of NR_CR_D, NR_ER_F, and NR_GR_H can also be independently morpholinyl, piperazinyl, pyrrolidinyl, or piperadinyl. Each of R_I and R_J is independently H, methyl, or ethyl. R_K is C₁₋₄ alkyl, C₃₋₄ alkenyl, C₃₋₄ alkynyl, C₃₋₆ cycloalkyl, or phenyl. X is O, S, or NH. Finally, each hydrocarbon radical or heterocyclic radical above is optionally substituted with between 1 and 3 substituents independently selected from halo, C₁₋₄ alkyl, C₃₋₆ cycloalkyl, C₁₋₄ alkenyl, C₁₋₄ alkynyl, phenyl, hydroxyl, amino, (amino)sulfonyl, and NO₂, wherein each substituent alkyl, cycloalkyl, alkenyl, alkynyl or phenyl is in turn optionally substituted with between 1 and 3 substituents independently selected from halo, C₁₋₂ alkyl, hydroxyl, amino, and NO₂. In addition to the above compounds, the invention also provides a pharmaceutically acceptable salt or C₁₋₇ ester thereof.

The invention also relates to a pharmaceutical composition including (a) a diarylamine (e.g., of formula I) and (b) a pharmaceutically acceptable carrier.

The invention further relates to a method for treating proliferative diseases, such as cancer, restenosis, psoriasis, autoimmune diseases, and atherosclerosis. Other aspects of the invention include methods for treating MEK-related cancer,

tumors of the breast, lung, colorectal, pancreas, prostate, brain, kidney, or ovary, and other solid or hematopoietic cancers. Further aspects of the invention include methods for treating or reducing the symptoms of xenograft (organ, cell(s), limb, skin, or bone marrow transplant) rejection, osteoarthritis, rheumatoid arthritis, cystic fibrosis, hepatomegaly, cardiomegaly, complications of diabetes (including diabetic nephropathy and diabetic retinopathy), stroke, heart failure, septic shock, asthma, and Alzheimer's disease. Compounds of the invention are also useful as antiviral agents for treating viral infections such as HIV, hepatitis (B) virus (HBV), human papilloma virus (HPV), cytomegalovirus (CMV), and Epstein-Barr virus (EBV). The methods include administering to a patient in need of such treatment, or suffering from such a disease or condition, a pharmaceutically effective amount of a disclosed compound or pharmaceutical composition thereof.

The invention also features methods of combination therapy, such as a method for treating cancer, wherein the method further includes providing radiation therapy or chemotherapy, for example, with mitotic inhibitors such as a taxane or a vinca alkaloid. Examples of mitotic inhibitors include paclitaxel, docetaxel, vincristine, vinblastine, vinorelbine, and vinflunine. Other therapeutic combinations include a MEK inhibitor of the invention and an anticancer agent such as cisplatin, 5-fluorouracil or 5-fluoro-2-4(1H,3H)-pyrimidinedione (5FU), flutamide, and gemcitabine.

The chemotherapy or radiation therapy may be administered before, concurrently, or after the administration of a disclosed compound according to the needs of the patient.

The invention also features synthetic intermediates and methods disclosed herein.

Other aspects of the invention are provided in the description, the examples, and the claims below.

30

DETAILED DESCRIPTION

The invention features diarylamine compounds of formula (I), pharmaceutical compositions thereof, and methods of using such compounds and compositions.

- 5 According to one aspect of the invention, the compounds are MEK inhibitors. MEK inhibition assays include the cascade assay for inhibitors of MAP kinase pathway described at column 6, line 36 to column 7, line 4 of U.S. Patent Number 5,525,625 and the in vitro MEK assay at column 7, lines 4-27 of the same patent, the entire disclosure of which is incorporated by reference (see also
10 Examples 2-5 below).

A. Terms

Certain terms are defined below and by their usage throughout this disclosure.

- 15 Alkyl groups include aliphatic (i.e., the subset of hydrocarbyl or hydrocarbon radical structures containing hydrogen and carbon atoms, but not containing heteroatoms in the skeleton, or unsaturated carbon-carbon bonds) with a free valence. Alkyl groups are understood to include straight chain and branched structures. Examples include methyl, ethyl, propyl, isopropyl, butyl, n-
20 butyl, isobutyl, t-butyl, pentyl, isopentyl, 2,3-dimethylpropyl, hexyl, 2,3-dimethyl hexyl, 1,1-dimethylpentyl, heptyl, and octyl. Cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and cyclooctyl.

- Alkyl groups can be substituted with 1, 2, 3 or more substituents which are independently selected from halo (fluoro, chloro, bromo, or iodo), hydroxy, amino,
25 alkoxy, alkylamino, dialkylamino, cycloalkyl, aryl, aryloxy, arylalkyloxy, heterocyclic radical, and (heterocyclic radical)oxy. Specific examples include fluoromethyl, hydroxyethyl, 2,3-dihydroxyethyl, (2- or 3-furanyl)methyl, cyclopropylmethyl, benzyloxyethyl, (3-pyridinyl)methyl, (2- or 3-furanyl)methyl, (2-thienyl)ethyl, hydroxypropyl, aminocyclohexyl, 2-dimethylaminobutyl,
30 methoxymethyl, N-pyridinylethyl, diethylaminoethyl, and cyclobutylmethyl.

Alkenyl groups are analogous to alkyl groups, but have at least one double bond (two adjacent sp^2 carbon atoms). Depending on the placement of a double

bond and substituents, if any, the geometry of the double bond may be *entgegen* (E), *zusammen* (Z), *cis*, or *trans*. Similarly, alkynyl groups have at least one triple bond (two adjacent sp carbon atoms). Unsaturated alkenyl or alkynyl groups may have one or more double or triple bonds, respectively, or a mixture thereof; like
5 alkyl groups, they may be straight chain or branched, and they may be substituted as described above and as exemplified throughout the disclosure. Examples of alkenyls, alkynyls, and substituted forms include *cis*-2-butenyl, *trans*-2-butenyl, 3-butenyl, 3-phenyl-2-propynyl, 3-(2'-fluorophenyl)-2-propynyl, 3-methyl(5-phenyl)-4-pentynyl, 2-hydroxy-2-propynyl, 2-methyl-2-
10 propynyl, 2-propenyl, 4-hydroxy-3-butenyl, 3-(3-fluorophenyl)-2-propynyl, and 2-methyl-2-propenyl. In formulae (I) and (II) alkenyls can be C₂₋₄ or C₂₋₈, and are preferably C₃₋₄ or C₃₋₈.

More general forms of substituted hydrocarbon radicals include hydroxyalkyl, hydroxyalkenyl, hydroxyalkynyl, hydroxycycloalkyl, hydroxyaryl, and
15 corresponding forms for the prefixes amino-, halo- (e.g., fluoro-, chloro-, or bromo-), nitro-, alkyl-, phenyl-, cycloalkyl- and so on, or combinations of substituents. According to formula (I), therefore, substituted alkyls include hydroxyalkyl, aminoalkyl, nitroalkyl, haloalkyl, alkylalkyl (branched alkyls, such as methylpentyl), (cycloalkyl)alkyl, phenylalkyl, alkoxy, alkylaminoalkyl,
20 dialkylaminoalkyl, arylalkyl, aryloxyalkyl, arylalkyloxyalkyl, (heterocyclic radical)alkyl, and (heterocyclic radical)oxyalkyl. R₁ thus includes hydroxyalkyl, hydroxyalkenyl, hydroxyalkynyl, hydroxycycloalkyl, hydroxyaryl, aminoalkyl, aminoalkenyl, aminoalkynyl, aminocycloalkyl, aminoaryl, alkylalkenyl, (alkylaryl)alkyl, (haloaryl)alkyl, (hydroxyaryl)alkynyl, and so forth. Similarly, R_A
25 includes hydroxyalkyl and aminoaryl, and R_B includes hydroxyalkyl, aminoalkyl, and hydroxyalkyl(heterocyclic radical)alkyl.

Heterocyclic radicals, which include but are not limited to heteroaryls, include: furyl, oxazolyl, isoxazolyl, thiophenyl, thiazolyl, pyrrolyl, imidazolyl, 1,3,4-triazolyl, tetrazolyl, pyridinyl, pyrimidinyl, pyridazinyl, indolyl, and their
30 nonaromatic counterparts. Further examples of heterocyclic radicals include piperidyl, quinolyl, isothiazolyl, piperidinyl, morpholinyl, piperazinyl,

tetrahydrofuryl, tetrahydropyrrolyl, pyrrolidinyl, octahydroindolyl, octahydrobenzothiofuranyl, and octahydrobenzofuranyl.

Selective MEK 1 or MEK 2 inhibitors are those compounds which inhibit the MEK 1 or MEK 2 enzymes, respectively, without substantially inhibiting other enzymes such as MKK3, PKC, Cdk2A, phosphorylase kinase, EGF, and PDGF receptor kinases, and C-src. In general, a selective MEK 1 or MEK 2 inhibitor has an IC_{50} for MEK 1 or MEK 2 that is at least one-fiftieth (1/50) that of its IC_{50} for one of the above-named other enzymes. Preferably, a selective inhibitor has an IC_{50} that is at least 1/100, more preferably 1/500, and even more preferably 1/1000, 1/5000, or less than that of its IC_{50} or one or more of the above-named enzymes.

B. Compounds

One aspect of the invention features disclosed compounds shown in formulae (I) and (II) in the Summary section. Embodiments of the invention includes compounds of formula (I) wherein: (a) R_3 is NO_2 ; (b) R_4 is fluoro; (c) each of R_3 and R_4 is independently selected from H and fluoro; (d) R_5 is methyl, fluoro, or chloro; (e) R_6 is methyl, chloro, fluoro, nitro, or hydrogen; (f) R_6 is H; (g) R_6 is fluoro; (h) R_K is methyl or ethyl; (i) R_1 is H, methyl, ethyl, propyl, isopropyl, isobutyl, benzyl, phenyl, phenethyl, allyl, C_{3-5} alkenyl, C_{3-6} cycloalkyl, $(C_{3-5} \text{ cycloalkyl})C_{1-2}$ alkyl, $(C_{3-5} \text{ heterocyclic radical})C_{1-2}$ alkyl, or $(CH_2)_{2-4} NR_C R_D$; (j) R_1 is H or $(C_{3-4} \text{ cycloalkyl})C_{1-2}$ alkyl; (k) R_2 is H or methyl; (l) R_A has at least one hydroxyl substituent; (m) R_A is H, methyl, ethyl, isobutyl, hydroxyethyl, phenyl, 2-piperidin-1-yl-ethyl, 2,3-dihydroxy-propyl, 3-[4-(2-hydroxyethyl)-piperazin-1-yl]-propyl, 2-pyrrolidin-1-yl-ethyl, or 2-diethylamino-ethyl; and R_B is H; or where R_B is methyl and R_A is phenyl; (n) W is $NR_A R_B$ or $NR_2 NR_A R_B$; (o) W is $NR_2 (CH_2)_{2-4} NR_A R_B$ or $O(CH_2)_{2-3} NR_A R_B$; (p) W is $NR_2 OR_1$; (q) W is OR_B ; (r) R_7 is in the para position relative to X; (s) R_7 is iodo; (t) R_8 is in the ortho position relative to X; (u) or combinations thereof.

In additional embodiments, if R_6 is H, then R_5 is nitro; or R_6 is methyl, halo, or nitro; or R_3 is $SO_2 NR_1 (CH_2)_{2-4} NR_E R_F$, $SO_2 NR_1 R_K$ or $(CO)T$. In some

embodiments, Ar is phenyl (e.g., formula (I)), and in other embodiments, Ar is 2-pyridyl, 3-pyridyl, or 4-pyridyl. Preferably, where one of R₁, R₂, R_A, R_B, R_C, and R_D is an alkenyl or alkynyl group, the double or triple bond, respectively, is not adjacent the point of attachment. For example, where W is NR₂OR₁, R₂ is preferably prop-2-ynyl, or but-2 or 3-enyl, and less preferably prop-1-ynyl or but-1-enyl. Some embodiments include the formula 2,4-bis-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-benzoic acid, the compounds in the following list, and 2-methyl (instead of 2-chloro) analogs thereof.

- 10 1. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-(4-sulfamoyl-phenylamino)-benzoic acid
2. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenylamino-benzoic acid
3. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenoxy-benzoic acid
- 15 4. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenylsulfanyl-benzoic acid
5. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-4-(methyl-phenyl-amino)-5-nitro-benzoic acid
6. 2-[(2-chloro-4-iodophenyl)amino]-3-fluoro-4-[[4-[(2-hydroxyethyl)amino]-carbonyl]phenyl]amino]-5-nitro-benzoic acid;
- 20 7. 2-[(2-chloro-4-iodophenyl)amino]-4-[[4-[(dimethylamino)carbonyl]phenyl]amino]-3-fluoro-5-nitro-benzoic acid;
8. 2-(2-Chloro-4-iodo-phenylamino)-3,5-difluoro-4-phenylamino-benzoic acid
9. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-(3-sulfamoyl-phenylamino)-benzoic acid;
- 25 10. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-(2-sulfamoyl-phenylamino)-benzoic acid;
11. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-(4-sulfamoyl-phenylamino)-benzamide;
- 30 12. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-phenylamino-benzamid ;

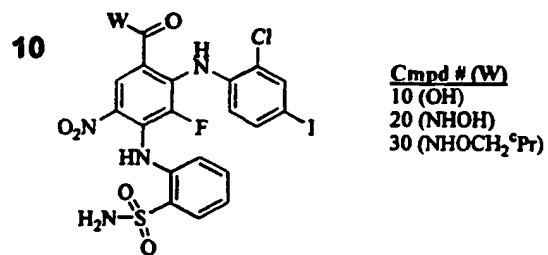
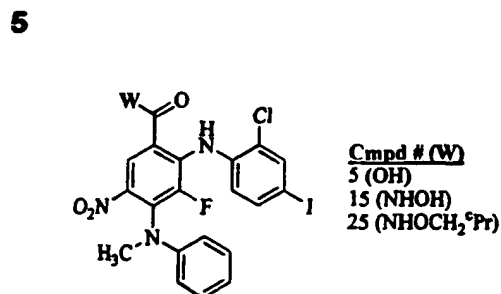
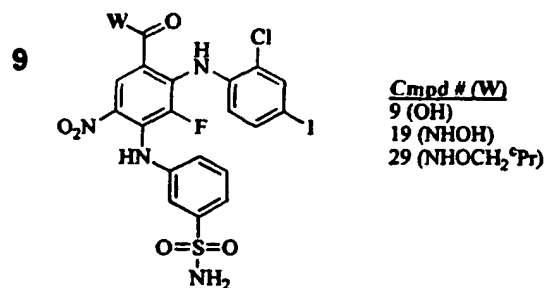
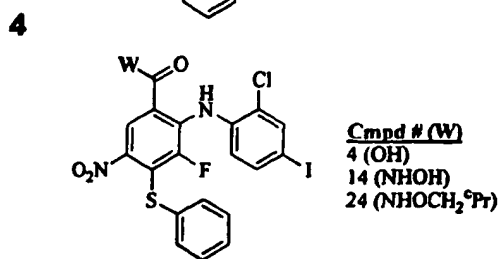
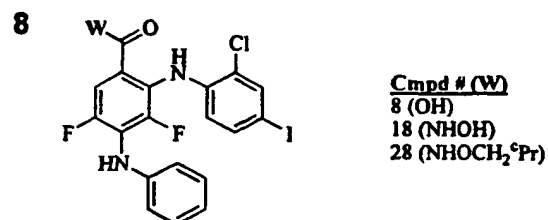
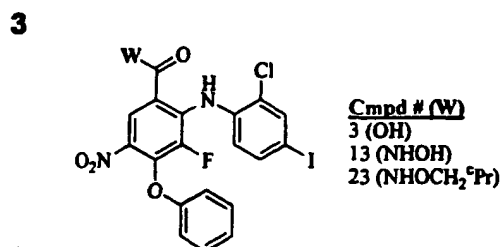
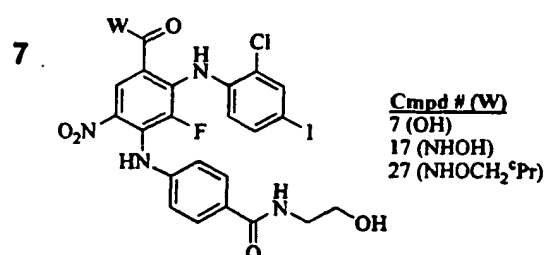
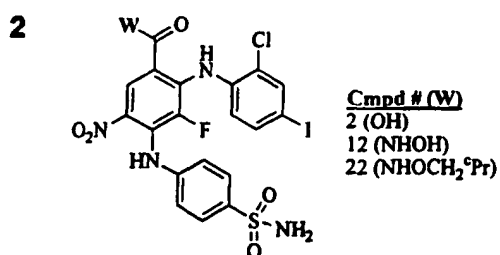
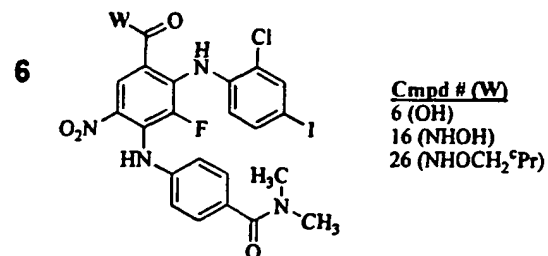
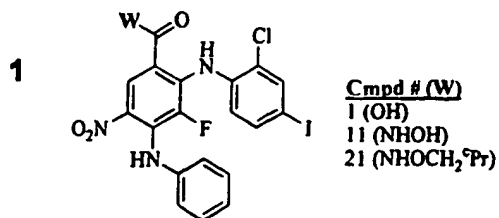
13. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-phenoxy-
b nzamide;
14. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-
phenylsulfanyl-benzamide;
- 5 15. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-4-(methyl-phenyl-
amino)-5-nitro-benzamide;
16. 2-[(2-chloro-4-iodophenyl)amino]-3-fluoro-N-hydroxy-4-[[4-[(2-
hydroxyethyl)amino]-carbonyl]phenyl]amino]-5-nitro-benzamide;
17. 2-[(2-chloro-4-iodophenyl)amino]-4-[[4-[(dimethylamino)carbonyl]
10 phenyl]amino]-3-fluoro-N-hydroxy-5-nitro-benzamide;
18. 2-(2-Chloro-4-iodo-phenylamino)-3,5-difluoro-N-hydroxy-4-phenylamino-
benzamide;
19. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-(3-
sulfamoyl-phenylamino)-benzamide;
- 15 20. 2-(2-Chloro-4-iodo-phenylamino)-3-fluoro-N-hydroxy-5-nitro-4-(2-
sulfamoyl-phenylamino)-benzamide;
21. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-
(4-sulfamoyl-phenylamino)-benzamide;
22. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-
20 phenylamino-benzamide;
23. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-
phenoxy-benzamide;
24. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-
phenylsulfanyl-benzamide;
- 25 25. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-4-
(methyl-phenyl-amino)-5-nitro-benzamide;
26. 2-[(2-chloro-4-iodophenyl)amino]-3-fluoro-N-cyclopropylmethoxy-4-[[4-[(2-
hydroxyethyl)amino]-carbonyl]phenyl]amino]-5-nitro-benzamide;
27. 2-[(2-chloro-4-iodophenyl)amino]-4-[[4-[(dimethylamino)carbonyl]phenyl]-
30 amino]-3-fluoro-N-cyclopropylmethoxy-5-nitro-benzamide;
28. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3,5-difluoro-4-
phenylamino-benzamide;

29. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-(3-sulfamoyl-phenylamino)-benzamide; and
30. 2-(2-Chloro-4-iodo-phenylamino)-N-cyclopropylmethoxy-3-fluoro-5-nitro-4-(2-sulfamoyl-phenylamino)-benzamide.

5

In the scheme below, W can also be any of the values described herein for formula (I) or (II) in the section describing preferred values for W. The compound numbers provided in the scheme correspond to the numbers provided in the above list; these compounds are illustrative, not limitative, of the invention.

10



C. Synthesis

The disclosed compounds can be synthesized according to the following two Schemes, or variants thereof (see also Example 1).

Regarding the first step of synthetic Scheme 1, the reaction of the aniline
5 and the benzoic acid derivative generally is accomplished by mixing the benzoic acid with an equimolar quantity or excess of the aniline in an unreactive organic solvent such as tetrahydrofuran, or toluene, in the presence of a base such as lithium diisopropylamide, lithium hexamethyldisilazide, n-butyl lithium, sodium hydride, or sodium amide. The reaction generally is carried out at a temperature
10 of about -78°C to about 25°C , and normally is complete within 2 hours to about 4 days. The product can be isolated by removing the solvent, for example by evaporation under reduced pressure, and further purified, if desired, by standard methods such as chromatography, crystallization, or distillation.

Turning to the second step, the 2-phenylamino benzoic acid derivative is
15 next reacted with an equimolar quantity or excess of a nucleophile such as an aniline, a phenol, or a thiophenol by mixing in an unreactive organic solvent such as tetrahydrofuran, or toluene, in the presence of a base such as lithium diisopropylamide, lithium hexamethyldisilazide, n-butyl lithium, sodium hydride, or sodium amide. The reaction generally is carried out at a temperature of about –
20 78°C to boiling, and normally is complete within 2 hours to about 4 days. The product can be isolated by removing the solvent, for example by evaporation under reduced pressure, and further purified, if desired, by standard methods such as chromatography, crystallization, or distillation.

Finally, regarding step 3, the 4-arylheteroatom-2-phenylamino benzoic
25 acid derivative next is reacted with a nucleophile such as ammonia, an amine, an alcohol, hydrazine, a hydrazine derivative, or a hydroxylamine derivative in the presence of a peptide coupling reagent. Amines that can be employed include monomethylamine and aniline. Alcohols that can be employed include cyclobutylmethanol and phenol. Hydrazine derivatives that can be employed
30 include N,N-dimethylhydrazine and 1-aminopiperidine. Hydroxylamine derivatives that can be employed include methoxylamine, N-ethyl-isopropoxy amine, and tetrahydrooxazine. Typical coupling reagents include 2-ethoxy-1-

ethoxycarbonyl-1,2-dihydroquinoline (EEDQ), 1,3-dicyclohexylcarbodiimide (DCC), bromo-tris-(pyrrolidino)-phosphonium hexafluorophosphate (PyBrOP) and (benzotriazolyloxy) tripyrrolidino phosphonium hexafluorophosphate (PyBOP).

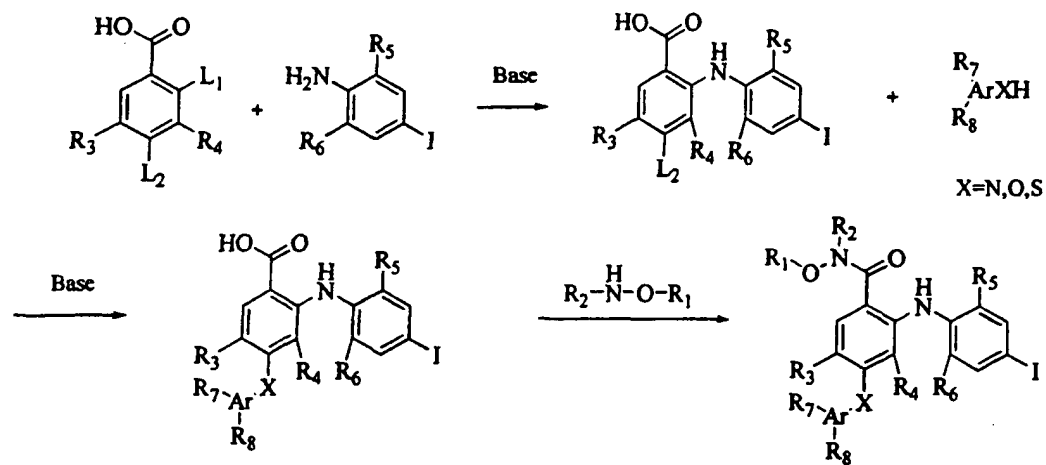
5 The 4-arylheteroatom-2-phenylamino benzoic acid derivative and the nucleophile normally are mixed in approximately equimolar quantities in an unreactive solvent such as dichloromethane, tetrahydrofuran, chloroform, or xylene, and an equimolar quantity of the coupling reagent is added. A base such as triethylamine or diisopropylethylamine can be added to act as an acid scavenger if desired. The coupling reaction generally is complete after about 10 minutes to
10 2 hours, and the product is readily isolated by removing the reaction solvent, for instance by evaporation under reduced pressure, and purifying the product by standard methods such as chromatography or crystallizations from solvents such as acetone diethyl ether or ethanol.

Referring to synthetic Scheme 2, an alternative method for making the
15 compounds of the invention involves first coupling the benzoic acid derivative with the arylheteroatom nucleophile, and then reacting this 4-arylheteroatom benzoic acid derivative with an aniline. The final step involves the coupling of the 4-arylheteroatom-2-phenylamino benzoic acid derivative with the ammonia, amine, alcohol, hydrazine, hydrazine derivative, or hydroxylamine derivative with
20 a peptide coupling reagent. The general reaction conditions for all of the steps in Scheme 2 are similar to those described above for synthetic Scheme 1.

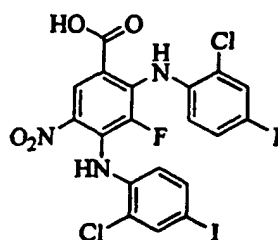
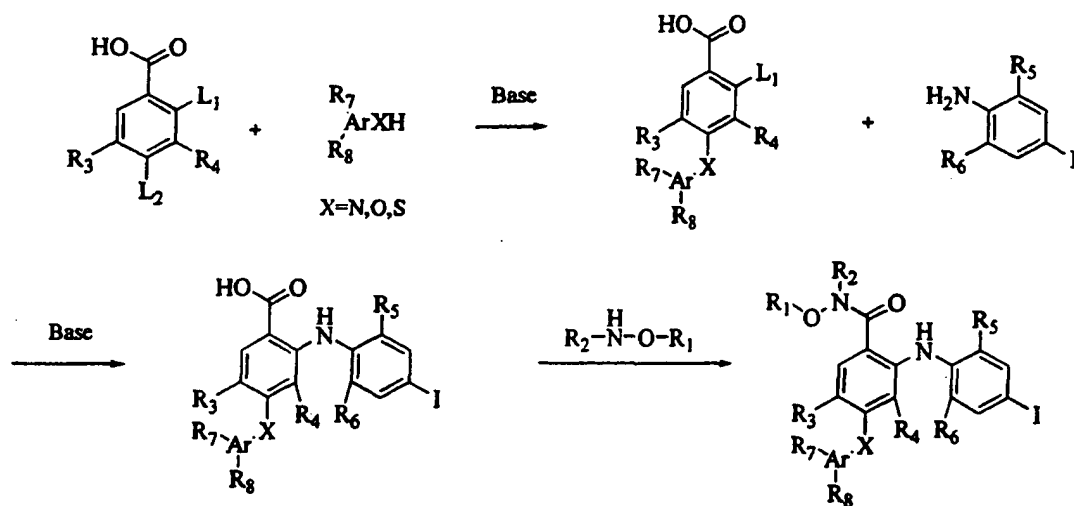
25

30

Scheme 1



Scheme 2



PD 195928
APK IC₅₀=30±8 nM

D. Uses

The disclosed compositions are useful as both prophylactic and therapeutic treatments for diseases or conditions as provided in the Summary section, as well as diseases or conditions modulated by the MEK cascade. Examples include stroke, heart failure, osteoarthritis, rheumatoid arthritis, organ transplant rejection, and a variety of tumors such as ovarian, lung, pancreatic, and colon.

1. Dosages

Those skilled in the art will be able to determine, according to known methods, the appropriate dosage for a patient, taking into account factors such as age, weight, general health, the type of pain requiring treatment, and the presence of other medications. In general, an effective amount will be between 0.1 and 1000 mg/kg per day, preferably between 1 and 300 mg/kg body weight, and daily dosages will be between 10 and 5000 mg for an adult subject of normal weight. Commercially available capsules or other formulations (such as liquids and film-coated tablets) of 100 mg, 200 mg, 300 mg, or 400 mg can be administered according to the disclosed methods.

2. Formulations

Dosage unit forms include tablets, capsules, pills, powders, granules, aqueous and nonaqueous oral solutions and suspensions, and parenteral solutions packaged in containers adapted for subdivision into individual doses. Dosage unit forms can also be adapted for various methods of administration, including controlled release formulations, such as subcutaneous implants. Administration methods include oral, rectal, parenteral (intravenous, intramuscular, subcutaneous), intracisternal, intravaginal, intraperitoneal, intravesical, local (drops, powders, ointments, gels, or cream), and by inhalation (a buccal or nasal spray).

Parenteral formulations include pharmaceutically acceptable aqueous or nonaqueous solutions, dispersion, suspensions, emulsions, and sterile powders for the preparation thereof. Examples of carriers include water, ethanol, polyols (propylene glycol, polyethylene glycol), vegetable oils, and injectable organic

est rs such as ethyl oleate. Fluidity can be maintained by the use of a coating such as lecithin, a surfactant, or maintaining appropriate particle size. Carriers for solid dosage forms include (a) fillers or extenders, (b) binders, (c) humectants, (d) disintegrating agents, (e) solution retarders, (f) absorption acccelerators, (g) adsorbants, (h) lubricants, (i) buffering agents, and (j) propellants.

Compositions may also contain adjuvants such as preserving, wetting, emulsifying, and dispensing agents; antimicrobial agents such as parabens, chlorobutanol, phenol, and sorbic acid; isotonic agents such as a sugar or sodium chloride; absorption-prolonging agents such as aluminum monostearate and gelatin; and absorption-enhancing agents.

3. Related compounds

The invention provides the disclosed compounds and closely related, pharmaceutically acceptable forms of the disclosed compounds, such as salts, esters, amides, hydrates or solvated forms thereof; masked or protected forms; and racemic mixtures, or enantiomerically or optically pure forms.

Pharmaceutically acceptable salts, esters, and amides include carboxylate salts (e.g., C₁₋₈ alkyl, cycloalkyl, aryl, heteroaryl, or non-aromatic heterocyclic), amino acid addition salts, esters, and amides which are within a reasonable benefit/risk ratio, pharmacologically effective, and suitable for contact with the tissues of patients without undue toxicity, irritation, or allergic response. Representative salts include hydrobromide, hydrochloride, sulfate, bisulfate, nitrate, acetate, oxalate, valerate, oleate, palmitate, stearate, laurate, borate, benzoate, lactate, phosphate, tosylate, citrate, maleate, fumarate, succinate, tartrate, naphthylate, mesylate, glucoheptonate, lactiobionate, and laurylsulfonate. These may include alkali metal and alkali earth cations such as sodium, potassium, calcium, and magnesium, as well as non-toxic ammonium, quaternary ammonium, and amine cations such as tetramethyl ammonium, methylamine, trimethylamine, and ethylamine. See, for example, S.M. Berge, et al., "Pharmaceutical Salts," *J. Pharm. Sci.*, 1977, 66:1-19 which is incorporated herein by reference. Representative pharmaceutically acceptable amides of the invention include those derived from ammonia, primary C₁₋₆ alkyl amines and secondary di (C₁₋₆ alkyl) amines. Secondary amines include 5- or 6-m mb red

h terocyclic or heteroaromatic ring moieties containing at least one nitrogen atom and optionally between 1 and 2 additional heteroatoms. Preferred amides are derived from ammonia, C₁₋₃ alkyl primary amines, and di (C₁₋₂ alkyl)amines. Representative pharmaceutically acceptable esters of the invention include C₁₋₇ alkyl, C₅₋₇ cycloalkyl, phenyl, and phenyl(C₁₋₆)alkyl esters. Preferred esters include methyl esters.

The invention also includes disclosed compounds having one or more functional groups (e.g., hydroxyl, amino, or carboxyl) masked by a protecting group. Some of these masked or protected compounds are pharmaceutically acceptable; others will be useful as intermediates. Synthetic intermediates and processes disclosed herein, and minor modifications thereof, are also within the scope of the invention.

HYDROXYL PROTECTING GROUPS

Hydroxyl protecting groups include: ethers, esters, and protection for 1,2- and 1,3-diols. The ether protecting groups include: methyl, substituted methyl ethers, substituted ethyl ethers, substituted benzyl ethers, silyl ethers and conversion of silyl ethers to other functional groups.

Substituted Methyl Ethers

Substituted methyl ethers include: methoxymethyl, methylthiomethyl, *t*-butylthiomethyl, (phenyldimethylsilyl) methoxymethyl, benzyloxymethyl, *p*-ethoxybenzyloxymethyl, (4-methoxyphenoxy) methyl, guaiacolmethyl, *t*-butoxymethyl, 4-pentenylloxymethyl, siloxymethyl, 2-methoxyethoxymethyl, 2,2,2-trichloroethoxymethyl, bis(2-chloro-ethoxy)methyl, 2-(trimethylsilyl)ethoxymethyl, tetrahydropyranyl, 3-bromotetrahydro-pyranyl, tetrahydrothiopyranyl, 1-methoxycyclohexyl, 4-methoxytetrahydropyranyl, 4-methoxytetrahydrothiopyranyl, 4-methoxytetrahydrothiopyranyl *S,S*-dioxido, 1-[(2-chloro-4-methyl)phenyl]-4-methoxypiperidin-4-yl, 1,4-dioxan-2-yl, tetrahydrofuranyl, tetrahydrothiofuranyl, and 2,3,3a,4,5,6,7,7a-octahydro-7,8,8-trimethyl-4,7-ethanobenzofuran-2-yl.

Substituted Ethyl Ethers

Substituted ethyl ethers include: 1-ethoxyethyl, 1-(2,chloroethoxy)ethyl,

1-methyl-1-methoxyethyl, 1-methyl-1-benzyloxyethyl, 1-methyl-1-benzyloxy-2-fluoroethyl, 2,2,2-trichloroethyl, 2-trimethylsilyl, 2-(phenylselenyl)ethyl, *t*-butyl, allyl, *p*-chlorophenyl, *p*-methoxyphenyl, 2,4-dinitrophenyl, and benzyl.

Substituted Benzyl Ethers

- 5 Substituted benzyl ethers include: *p*-methoxybenzyl, 3,4-dimethoxybenzyl, *o*-nitrobenzyl, *p*-nitrobenzyl, *p*-halobenzyl, 2,6-dichlorobenzyl, *p*-cyanobenzyl, *p*-phenylbenzyl, 2- and 4-picolyl, 3-methyl-2-picolyl *N*-oxido, diphenylmethyl, *p*, *p*'-dinitrobenzhydryl, 5-dibenzosuberyl, triphenylmethyl, α -naphthylidiphenylmethyl, *p*-methoxyphenyldiphenylmethyl, di(*p*-methoxyphenyl)phenylmethyl, tri-(*p*-methoxyphenyl)methyl, 4-(4'-bromophenacyloxy)phenyldiphenylmethyl, 4,4',4''-tris(4,5-dichlorophthalimido-phenyl)methyl, 4,4',4''-tris(levulinoyloxyphenyl) methyl, 4,4',4''tris(benzoylox-phenyl)methyl, 3-(imidazol-1-ylmethyl)bis(4',4''-dimethoxyphenyl)-methyl, 1,1-bis(4-methoxyphenyl)-1'-pyrenylmethyl, 9-anthryl, 9-(9-phenyl) xanthenyl, 9-(9-phenyl-10-oxo) anthryl, 1,3-benzodithiolan-2-yl, and benzisothiazolyl S,S-dioxido.
- 10
- 15

Silyl Ethers

- Silyl ethers include: trimethylsilyl, triethylsilyl, triisopropylsilyl, dimethylisopropylsilyl, diethylisopropylsilyl, dimethylthexylsilyl, *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl, tribenzylsilyl, tri-*p*-xylylsilyl, triphenylsilyl, diphenylmethylsilyl, and *t*-butylmethoxyphenylsilyl.
- 20

ESTERS

Esters protecting groups include: esters, carbonates, assisted cleavage, miscellaneous esters, and sulfonates.

Esters

- 25 Examples of protective esters include: formate, benzoylformate, acetate, chloroacetate, dichloroacetate, trichloroacetate, trifluoroacetate, methoxyacetate, triphenylmethoxyacetate, phenoxyacetate, *p*-chlorophenoxyacetate, *p*-P-phenylacetate, 3-phenylpropionate, 4-oxopentanoate (levulinate), 4,4-
- 30 (ethylenedithio) pentanoate, pivaloate, adamantate, crotonate, 4-

methoxycrotonate, benzoate, *p*-phenylbenzoate, and 2,4,6-trimethylbenzoate (mesitoate).

Carbonates

- Carbonates include: methyl, 9-fluorenylmethyl, ethyl, 2,2,2-trichloroethyl,
 5 2-(trimethylsilyl) ethyl, 2-(phenylsulfonyl) ethyl, 2-(triphenylphosphonio) ethyl, isobutyl, vinyl, allyl, *p*-nitrophenyl, benzyl, *p*-methoxybenzyl, 3,4-dimethoxybenzyl, *o*-nitrobenzyl, *p*-nitrobenzyl, S-benzyl thiocarbonate, 4-ethoxy-1-naphthyl, and methyl dithiocarbonate.

Assisted Cleavage

- 10 Examples of assisted cleavage protecting groups include: 2-iodobenzoate, 4-azido-butylate, 4-nitro-4-methylpentanoate, *o*-(dibromomethyl) benzoate, 2-formylbenzene-sulfonate, 2-(methylthiomethoxy) ethyl carbonate, 4-(methylthio-methoxymethyl) benzoate, and 2-(methylthiomethoxymethyl) benzoate.

15 Miscellaneous Esters

- In addition to the above classes, miscellaneous esters include: 2,6-dichloro-4-methylphenoxyacetate, 2,6-dichloro-4-(1,1,3,3-tetramethylbutyl) phenoxyacetate, 2,4-bis(1,1-dimethylpropyl) phenoxyacetate, chlorodiphenylacetate, isobutyrate, monosuccinoate, (*E*)-2-methyl-2-butenate (tigloate), *o*-(methoxycarbonyl)
 20 benzoate, *p*-P-benzoate, α -naphthoate, nitrate, alkyl *N,N,N',N'*-tetramethylphosphorodiamidate, *N*-phenylcarbamate, borate, dimethylphosphinothioyl, and 2,4-dinitrophenylsulfenate.

Sulfonates

- Protective sulfates includes: sulfate, methanesulfonate(mesylate),
 25 benzylsulfonate, and tosylate.

PROTECTION FOR 1,2- AND 1,3-DIOLS

The protection for 1,2 and 1,3-diols group includes: cyclic acetals and ketals, cyclic ortho esters, and silyl derivatives.

30 Cyclic Acetals and Ketals

Cyclic acetals and ketals includ : methylene, ethylidene, 1-*t*-butylethylidene,

1-phenylethylidene, (4-methoxyphenyl) ethylidene, 2,2,2-trichloroethylidene, acetone (isopropylidene), cyclopentylidene, cyclohexylidene, cycloheptylidene, benzylidene, *p*-methoxybenzylidene, 2,4-dimethoxybenzylidene, 3,4-dimethoxybenzylidene, and 2-nitrobenzylidene.

5 Cyclic Ortho Esters

Cyclic ortho esters include: methoxymethylene, ethoxymethylene, dimethoxymethylene, 1-methoxyethylidene, 1-ethoxyethylidene, 1,2-dimethoxyethylidene, α -methoxybenzylidene, 1-(*N,N*-dimethylamino)ethylidene derivative, α -(*N,N*-dimethylamino) benzylidene derivative, and 2-oxacyclopentylidene.

10

PROTECTION FOR THE CARBOXYL GROUP

ESTERS

Ester protecting groups include: esters, substituted methyl esters, 2-substituted ethyl esters, substituted benzyl esters, silyl esters, activated esters,

15 miscellaneous derivatives, and stannyl esters.

Substituted Methyl Esters

Substituted methyl esters include: 9-fluorenylmethyl, methoxymethyl, methylthiomethyl, tetrahydropyranyl, tetrahydrofuranyl, methoxyethoxymethyl, 2-(trimethylsilyl)ethoxy-methyl, benzyloxymethyl, phenacyl, *p*-bromophenacyl, α -methylphenacyl, *p*-methoxyphenacyl, carboxamidomethyl, and *N*-phthalimidomethyl.

20

2-Substituted Ethyl Esters

2-Substituted ethyl esters include: 2,2,2-trichloroethyl, 2-haloethyl, 1-chloroalkyl, 2-(trimethylsilyl)ethyl, 2-methylthioethyl, 1,3-dithianyl-2-methyl, 2-(*p*-nitrophenylsulfenyl)-ethyl, 2-(*p*-toluenesulfonyl)ethyl, 2-(2'-pyridyl)ethyl, 2-(diphenylphosphino)ethyl, 1-methyl-1-phenylethyl, *t*-butyl, cyclopentyl, cyclohexyl, allyl, 3-buten-1-yl, 4-(trimethylsilyl)-2-buten-1-yl, cinnamyl, α -methylcinnamyl, phenyl, *p*-(methylmercapto)-phenyl, and benzyl.

25

30 Substituted Benzyl Esters

Substituted benzyl esters include: triphenylmethyl, diphenylmethyl,

- bis(*o*-nitrophenyl)methyl, 9-anthrylmethyl, 2-(9,10-dioxo)anthrylmethyl, 5-dibenzo-suberyl, 1-pyrenylmethyl, 2-(trifluoromethyl)-6-chromylmethyl, 2,4,6-trimethylbenzyl, *p*-bromobenzyl, *o*-nitrobenzyl, *p*-nitrobenzyl, *p*-methoxybenzyl, 2,6-dimethoxybenzyl, 4-(methylsulfinyl)benzyl, 4-sulfobenzyl, piperonyl, and 4-P-
5 benzyl.

Silyl Esters

Silyl esters include: trimethylsilyl, triethylsilyl, *t*-butyldimethylsilyl, *i*-propyldimethylsilyl, phenyldimethylsilyl, and di- *t*-butylmethylsilyl.

Miscellaneous Derivatives

- 10 Miscellaneous derivatives includes: oxazoles, 2-alkyl-1,3-oxazolines, 4-alkyl-5-oxo-1,3-oxazolidines, 5-alkyl-4-oxo-1,3-dioxolanes, ortho esters, phenyl group, and pentaaminocobalt(III) complex.

Stannyl Esters

Examples of stannyl esters include: triethylstannyl and tri-*n*-butylstannyl.

15

AMIDES AND HYDRAZIDES

- Amides include: *N,N*-dimethyl, pyrrolidinyl, piperidinyl, 5,6-dihydrophenanthridinyl, *o*-nitroanilides, *N*-7-nitroindolyl, *N*-8-nitro-1,2,3,4-tetrahydroquinolyl, and *p*-P-benzenesulfonamides. Hydrazides include: *N*-phenyl, *N,N'*-diisopropyl
20 and other dialkyl hydrazides.

PROTECTION FOR THE AMINO GROUP

CARBAMATES

- 25 Carbamates include: carbamates, substituted ethyl, assisted cleavage, photolytic cleavage, urea-type derivatives, and miscellaneous carbamates.

Carbamates

- Carbamates include: methyl and ethyl, 9-fluorenylmethyl, 9-(2-sulfo)fluorenylmethyl, 9-(2,7-dibromo)fluorenylmethyl, 2,7-di-*t*-butyl-[9-(10,10-dioxo-
30 10,10,10,10-tetrahydro- thioxanthyl)]methyl, and 4-methoxyphenacyl.

Substituted Ethyl

Substituted ethyl protective groups include: 2,2,2-trichloroethyl, 2-trimethylsilylethyl, 2-phenylethyl, 1-(1-adamantyl)-1-methylethyl, 1,1-dimethyl-2-haloethyl, 1,1-dimethyl-2,2-dibromoethyl, 1,1-dimethyl-2,2,2-trichloroethyl, 1-methyl-1-(4-biphenyl)ethyl, 1-(3,5-di-*t*-butylphenyl)-1-methylethyl, 2-(2'-and 4'-pyridyl)ethyl, 2-(*N,N*-isyclohexylcarboxamido)- ethyl, *t*-butyl, 1-adamantyl, vinyl, allyl, 1-isopropylallyl, connamyl, 4-nitrocinnamyl, quinolyl, *N*-hydroxypiperidiny, alkyldithio, benzyl, *p*-methoxybenzyl, *p*-nitrobenzyl, *p*-bromobenzyl, *p*-chlorobenzyl, 2,4dichlorobenzyl, 4-methylsulfinylbenzyl, 9-anthrylmethyl, and diphenylmethyl.

Assisted Cleavage

Protection via assisted cleavage includes: 2-methylthioethyl, 2-methylsulfonylethyl, 2-(*p*-toluenesulfonyl)ethyl, [2-(1,3-dithianyl)]methyl, 4-methylthiophenyl, 2,4-dimethyl-thiophenyl, 2-phosphonioethyl, 2-triphenylphosphonioisopropyl, 1,1-dimethyl-2cyanoethyl, *m*-chloro-*p*-acyloxybenzyl, *p*-(dihydroxyboryl)benzyl, 5-benzisoxazolyl-methyl, and 2-(trifluoromethyl)-6-chromonylmethyl.

Photolytic Cleavage

Photolytic cleavage methods use groups such as: *m*-nitrophenyl, 3,5-dimethoxybenzyl, *o*-nitrobenzyl, 3,4-dimethoxy-6-nitrobenzyl, and phenyl(*o*-nitrophenyl)methyl.

Urea-Type Derivatives

Examples of of urea-type derivatives include: phenothiazinyl-(10)-carbonyl derivative, *N*'-*p*-toluenesulfonylaminocarbonyl, and *N*'-phenylaminothiocarbonyl.

Miscellaneous Carbamates

In addition to the above, miscellaneous carbamates include: *t*-amyl, *S*-benzyl thiocarbamate, *p*-cyanobenzyl, cyclobutyl, cyclohexyl, cyclopentyl, cyclopropylmethyl, *p*-decyloxy-benzyl, diisopropylmethyl, 2,2-dimethoxycarbonylvinyl, *o*-(*N,N*-dimethyl-carboxamido)-benzyl, 1,1-dimethyl-3(*N,N*-dimethylcarboxamido)propyl, 1,1-dimethyl-propynyl, di(2-pyridyl)methyl, 2-

- furanylmethyl, 2-iodoethyl, isobornyl, isobutyl, isonicotiny, *p*(*p*'-methoxyphenylazo)benzyl, 1-methylcyclobutyl, 1-methylcyclohexyl, 1-methyl-1-cyclopropylmethyl, 1-methyl-(3,5-dimethoxyphenyl)ethyl, 1-methyl-1(*p*-henylazophenyl)-ethyl, 1-methyl-1-phenylethyl, 1-methyl-1-(4-pyridyl)ethyl, 5 phenyl, *p*-(phenylazo)benzyl, 2,4,6-tri-*t*-butylphenyl, 4-(trimethylammonium)benzyl, and 2,4,6-trimethylbenzyl.

AMIDES

Amides

- 10 Amides includes: *N*-formyl, *N*-acetyl, *N*-chloroacetyl, *N*-trichloroacetyl, *N*-trifluoroacetyl, *N*-phenylacetyl, *N*-3-phenylpropionyl, *N*-picolinoyl, *N*-3-pyridyl-carboxamide, *N*-benzoylphenylalanyl derivative, *N*-benzoyl, and *N*-*p*-phenylbenzoyl.

Assisted Cleavage

- 15 Assisted cleavage groups include: *N*-*o*-nitrophenylacetyl, *N*-*o*-nitrophenoxyacetyl, *N*-acetoacetyl, (*N*'-dithiobenzyloxycarbonylamino)acetyl, *N*-3-(*p*-hydroxyphenyl) propionyl, *N*-3-(*o*-nitrophenyl)propionyl, *N*-2-methyl-2-(*o*-nitrophenoxy)propionyl, *N*-2-methyl-2-(*o*-phenylazophenoxy)propionyl, *N*-4-chlorobutyryl, *N*-3-methyl-3-nitrobutyryl, *N*-*o*-nitrocinnamoyl, *N*-acetylmethionine 20 derivative, *N*-*o*-nitrobenzoyl, *N*-*o*-(benzoyloxymethyl)benzoyl, and 4,5-diphenyl-3-oxazolin-2-one.

Cyclic Imide Derivatives

- Cyclic imide derivatives include: *N*-phthalimide, *N*-dithiasuccinoyl, *N*-2,3-diphenyl-maleoyl, *N*-2,5-dimethylpyrrolyl, 25 *N*-1,1,4,4-tetramethyldisilylazacyclopentane adduct, 5-substituted 1,3-dimethyl-1,3,5-triazacyclohexan-2-one, 5-substituted 1,3-dibenzyl-1,3,5-triazacyclohexan-2-one, and 1-substituted 3,5-dinitro-4-pyridonyl.

SPECIAL -NH PROTECTIVE GROUPS

Protective groups for -NH include: *N*-alkyl and *N*-aryl amines, imine derivatives, enamine derivatives, and *N*-hetero atom derivatives (such as *N*-metal, *N*-N, *N*-P,

- 5 *N*-Si, and *N*-S), *N*-sulfenyl, and *N*-sulfonyl.

N-Alkyl and *N*-Aryl Amines

N-alkyl and *N*-aryl amines include: *N*-methyl, *N*-allyl, *N*-[2-(trimethylsilyl)ethoxyl]-methyl, *N*-3-acetoxypentyl, *N*-(1-isopropyl-4-nitro-2-oxo-3-pyrrolin-3-yl), quaternary ammonium salts, *N*-benzyl, *N*-di(4-methoxyphenyl)methyl,

- 10 *N*-5-dibenzosuberyl, *N*-triphenylmethyl, *N*-(4-methoxyphenyl)diphenylmethyl, *N*-9-phenylfluorenyl, *N*-2,7-dichloro-9-fluorenylmethylene, *N*-ferrocenylmethyl, and *N*-2-picolylamine *N*'-oxide.

Imine Derivatives

Imine derivatives include: *N*-1,1-dimethylthiomethylene, *N*-benzylidene,

- 15 *N*-*p*-methoxybenzylidene, *N*-diphenylmethylene, *N*-[(2-pyridyl)mesityl]methylene, *N*-(*N*',*N*'-dimethylaminomethylene), *N,N*'-isopropylidene, *N*-*p*-nitrobenzylidene, *N*-salicylidene, *N*-5-chlorosalicylidene, *N*-(5-chloro-2-hydroxyphenyl)phenylmethylene, and *N*-cyclohexylidene.

Enamine Derivative

- 20 An example of an enamine derivative is *N*-(5,5-dimethyl-3-oxo-1-cyclohexenyl).

N-Hetero Atom Derivatives

N-metal derivatives include: *N*-borane derivatives, *N*-diphenylborinic acid derivative, *N*-[phenyl(pentacarbonylchromium- or -tungsten)]carbenyl, and *N*-copper or *N*-zinc chelate. Examples of *N*-N derivatives include: *N*-nitro,

- 25 *N*-nitroso, and *N*-oxide. Examples of *N*-P derivatives include: *N*-diphenylphosphinyl, *N*-dimethylthiophosphinyl, *N*-diphenylthiophosphinyl, *N*-dialkyl phosphoryl, *N*-dibenzyl phosphoryl, and *N*-diphenyl phosphoryl. Examples of *N*-sulfenyl derivatives include: *N*-benzenesulfenyl, *N*-*o*-nitrobenzenesulfenyl, *N*-2,4-dinitrobenzenesulfenyl,
- 30 *N*-pentachlorobenzenesulfenyl, *N*-2-nitro-4-methoxy-benzenesulfenyl, *N*-triphenylmethylsulfenyl, and *N*-3-nitropyridinesulfenyl. *N*-sulfonyl derivatives include: *N*-*p*-toluenesulfonyl, *N*-benzen sulfonyl, *N*-2,3,6-trimethyl-

4-methoxybenzenesulfonyl, *N*-2,4,6-trimethoxybenzenesulfonyl, *N*-2,6-dimethyl-4-methoxybenzenesulfonyl, *N*-pentamethylbenzenesulfonyl, *N*-2,3,5,6-tetramethyl-4-methoxybenzenesulfonyl, *N*-4-methoxybenzenesulfonyl, *N*-2,4,6-trimethylbenzenesulfonyl, *N*-2,6-dimethoxy-4-methylbenzenesulfonyl, *N*-2,2,5,7,8-pentamethylchroman-6-sulfonyl, *N*-methanesulfonyl, *N*- β -trimethylsilylethanesulfonyl, *N*-9-anthracenesulfonyl, *N*-4-(4',8'-dimethoxynaphthylmethyl)-benzenesulfonyl, *N*-benzylsulfonyl, *N*-trifluoromethylsulfonyl, and *N*-phenacetylulfonyl.

10 Disclosed compounds which are masked or protected may be prodrugs, compounds metabolized or otherwise transformed *in vivo* to yield a disclosed compound, e.g., transiently during metabolism. This transformation may be a hydrolysis or oxidation which results from contact with a bodily fluid such as blood, or the action of acids, or liver, gastrointestinal, or other enzymes.

15 Features of the invention are further described in the examples below.

E. Examples

EXAMPLE 1

5

Preparation of 2,4-bis-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitrobenzoic acid

Step a: Preparation of 5-nitro-2,3,4-trifluorobenzoic acid

To gently stirring concentrated sulfuric acid (50 ml) was added fuming
10 nitric acid (3.4 ml, 0.076 mol). Solid 2,3,4-trifluorobenzoic acid (10.00 g, 0.05565
mol) was added directly in increments. After stirring 45 minutes, the reaction
mixture had become an orange homogeneous solution which was then poured
over chilled water (400 ml). The resulting aqueous suspension was extracted
with diethyl ether (3 x 200 ml). The combined extracts were dried with anhydrous
15 magnesium sulfate and concentrated *in vacuo* to yield 12.30 g of a dull, light-
yellow solid. Recrystallization from chloroform (50 ml) afforded 9.54 g of the pale
yellow microcrystalline product; 78 % yield; m.p. ; ¹H-NMR (400 MHz; DMSO) δ
14.29 (broad s, 1H), 8.43-8.38 (m, 1H); ¹³C-NMR (100 MHz; DMSO) δ 162.41,
154.24 (dd, J_{C-F}=270.1, 10.7 Hz), 148.35 (dd, J_{C-F}=267.0, 9.2 Hz), 141.23 (dt, J_{C-}
20 F=253.4 Hz), 133.95, 123.30 (d, J_{C-F}=2.2 Hz), 116.92 (dd, J_{C-F}=18.2, 3.8 Hz); ¹⁹F-
NMR (376 MHz; DMSO) δ -120.50 to -120.63 (m), -131.133 to -131.27 (m), -
153.63 to -153.74 (m).

Step b: Preparation of 2,4-bis-(2-chloro-4-iodo-phenylamino)-3-fluoro-5- 25 nitrobenzoic acid

To a stirring solution comprised of 2-chloro-4-iodoaniline (Lancaster, 98 %, 12.33 g, 0.04864 mol) in tetrahydrofuran (20 ml) at -78 °C under nitrogen was added a 2.0 M lithium diisopropylamide solution in tetrahydrofuran-heptane-ethylbenzene (Aldrich, 35 ml, 0.070 mol) with a syringe. The addition formed a
30 thick suspension. After five minutes of stirring, a solution comprised of 5-nitro-2,3,4-trifluorobenzoic acid (5.00 g, 0.0226 mol) in tetrahydrofuran (30 ml) was added with a syringe to give a dark reaction mixture. The cold bath was removed

and the reaction mixture stirred for 20 minutes. The cool reaction mixture was poured into ether (600 ml) containing an excess of hydrogen chloride. The red solution instantly turned to a yellow suspension as a precipitate formed. This precipitate was removed by vacuum filtration. The filtrate was concentrated *in vacuo* to a red powder (10.5 g). The red powder was triturated with boiling chloroform (800 ml). The triturated solids were collected by vacuum filtration to give an orange powder (2.42 g). The mother liquor from the trituration was concentrated *in vacuo* to give a red-orange solid (ca. 10 g undried). This solid was loaded onto a flash silica column. Elution with dichloromethane removed some impurities. Continuing elution with 1 % methanol in dichloromethane afforded ca. 4 g of a red solid. This red solid was dissolved in hot absolute ethanol (100 ml). The solution was boiled down to 50 ml before dilution to 300 ml with hexanes. This solution was boiled to 150 ml and rediluted to 300 ml with hexanes to produce slight turbidity. The mixture was cooled in the refrigerator for three days, affording a yellow precipitate. The precipitate was collected by vacuum filtration and was dried with suction to afford 0.15 g of a yellow solid; 1 % yield; ¹H-NMR (400 MHz; DMSO) δ 8.94 (s, 1H), 8.55 (s, 1H), 7.79 (d, 2H, J=2.0 Hz), 7.61-7.57 (m, 2H), 6.90 (dd, 1H, J=8.5, 3.9 Hz), 6.84 (dd, 1H, J=8.3, 6.6 Hz); ¹⁹F-NMR (376 MHz; DMSO) δ -122.62 (s); MS (APCI+) 692 (6), 691 (8), 690 (31), 689 (10), 688 (55), 171 (47), 130 (100); (APCI-) 691 (4), 690 (12), 689 (14), 688 (70), 687 (32), 686 (100), 506 (50), 453 (97); IR (KBr) 1523 cm⁻¹; Anal. calcd/found for: C₁₉H₁₀Cl₂Fl₂N₃O₄ C, 33.17/33.32; H, 1.47/1.73; N, 6.11/5.73; Cl, 10.31/10.04; F, 2.76/3.70; I, 36.89/34.32.

The APK IC₅₀ for 2,4-bis-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitrobenzoic acid is 29.6 nM.

EXAMPLE 2

30 Cascade assay for inhibitors of the MAP kinase pathway

Incorporation of ³²P into myelin basic protein (MBP) is assayed in the presence of a glutathione S-transferase fusion protein containing p44MAP kinase (GST-MAPK) and a glutathione S-transferase fusion prot in containing p45MEK

(GST-MEK). The assay solution contains 20 mM HEPES, pH 7.4, 10 mM $MgCl_2$, 1 mM $MnCl_2$, 1 mM EGTA, 50 μM $[\gamma\text{-}^{32}P]ATP$, 10 μg GST-MEK, 0.5 μg GST-MAPK and 40 μg MBP in a final volume of 100 μL . Reactions are stopped after 20 minutes by addition of trichloroacetic acid and filtered through a GF/C filter mat. ^{32}P retained on the filter mat is determined using a 120S Betaplate. Compounds are assessed at 10 μM for ability to inhibit incorporation of ^{32}P .

To ascertain whether compounds are inhibiting GST-MEK or GST MAPK, two additional protocols are employed. In the first protocol, compounds are added to tubes containing GST-MEK, followed by addition of GST-MAPK, MBP and $[\gamma\text{-}^{32}P]ATP$. In the second protocol, compounds are added to tubes containing both GST-MEK and GST-MAPK, followed by MBP and $[\gamma\text{-}^{32}P]ATP$.

Compounds that show activity in both protocols are scored as MAPK inhibitors, while compounds showing activity in only the first protocol are scored as MEK inhibitors.

EXAMPLE 3

In vitro MAP kinase assay

Inhibitory activity can be confirmed in direct assays. For MAP kinase, 1 μg GST-MAPK is incubated with 40 μg MBP for 15 minutes at 30°C in a final volume of 50 μL containing 50 mM Tris (pH 7.5), 10 μM $MgCl_2$, 2 μM EGTA, and 10 μM $[\gamma\text{-}^{32}P]ATP$. The reaction is stopped by addition of Laemmli SDS sample buffer and phosphorylated MBP resolved by electrophoresis on a 10% polyacrylamide gel. Radioactivity incorporated into MBP is determined by both autoradiography, and scintillation counting of excised bands.

EXAMPLE 4

In vitro MEK assay

For evaluation of direct MEK activity, 10 μg GST-MEK₁ is incubated with 5 μg of a glutathione S-transferase fusion protein containing p44MAP kinase with a lysine to alanine mutation at position 71 (GST-MAPK-KA). This mutation eliminates kinase activity of MAPK, so only kinase activity attributed to the added

MEK remains. Incubations are 15 minutes at 30°C in a final volume of 50 µL containing 50 mM Tris (pH 7.5), 10 µM MgCl₂, 2 µM EGTA, and 10 µM [γ-³²P]ATP. The reaction is stopped by addition of Laemmli SDS sample buffer. Phosphorylated GST-MAPK-KA is resolved by electrophoresis on a 10% polyacrylamide gel. Radioactivity incorporated into GST-MAPK-KA is determined by autoradiography, and subsequent scintillation counting of excised bands. Additionally, an artificially activated MEK containing serine to glutamate mutations at positions 218 and 222 (GST-MEK-2E) is used. When these two sites are phosphorylated, MEK activity is increased. Phosphorylation of these sites can be mimicked by mutation of the serine residues to glutamate. For this assay, 5 µg GST-MEK-2E is incubated with 5 µg GST-MAPK-KA for 15 minutes at 30°C in the same reaction buffer as described above. Reactions are terminated and analyzed as above.

15 EXAMPLE 5

Whole cell MAP kinase assay

To determine if compounds block activation of MAP kinase in whole cells, the following protocol is used. Cells are plated in multi-well plates and grown to confluence. Cells are serum-deprived overnight. Cells are exposed to the desired concentrations of compound or vehicle (DMSO) for 30 minutes, followed by addition of a growth factor, for example, PDGF (100 ng/mL). After a 5-minute treatment with the growth factor, cells are washed with PBS, and lysed in a buffer consisting of 70 mM NaCl, 10 mM HEPES (pH 7.4), 50 mM glycerol phosphate, and 1% Triton X-100. Lysates are clarified by centrifugation at 13,000 x g for 10 minutes. Five micrograms of the resulting supernatants are incubated with 10 µg microtubule associated protein-2 (Map2) for 15 minutes at 30°C in a final volume of 25 µL containing 50 mM Tris (pH 7.4), 10 mM MgCl₂, 2 mM EGTA and 30 µM [γ-³²P]ATP. Reactions are terminated by addition of Laemmli sample buffer. Phosphorylated Map2 is resolved on 7.5% acrylamide gels and incorporated radioactivity is determined by scintillation counting of excised bands.

EXAMPLE 6

Monolayer growth

- Cells are plated into multi-well plates at 10 to 20,000 cells/mL. Forty-eight hours after seeding, test compounds are added to the cell growth medium and incubation is continued for 2 additional days. Cells are then removed from the wells by incubation with trypsin and enumerated with a Coulter counter.

EXAMPLE 7

Growth in soft-agar

- Cells are seeded into 35-mm dishes at 5 to 10,000 cells/dish using growth medium containing 0.3% agar. After chilling to solidify the agar, cells are transferred to a 37°C incubator. After 7 to 10 days' growth, visible colonies are manually enumerated with the aid of a dissecting microscope.

EXAMPLE 8

Collagen-Induced Arthritis in Mice

- Type II collagen-induced arthritis (CIA) in mice is an experimental model of arthritis that has a number of pathologic, immunologic, and genetic features in common with rheumatoid arthritis. The disease is induced by immunization of DBA/1 mice with 100 µg type II collagen, which is a major component of joint cartilage, delivered intradermally in Freund's complete adjuvant. The disease susceptibility is regulated by the class II MHC gene locus, which is analogous to the association of rheumatoid arthritis with HLA-DR4.

- A progressive and inflammatory arthritis develops in the majority of mice immunized, characterized by paw width increases of up to 100%. A test compound is administered to mice in a range of amounts, such as 20, 60, 100, and 200 mg/kg body weight/day. The duration of the test can be several weeks to a few months, such as 40, 60, or 80 days. A clinical scoring index is used to assess disease progression from erythema and edema (stage 1), joint distortion (stage 2), to joint ankylosis (stage 3). The disease is variable in that it can affect one or all paws in an animal, resulting in a total possible score of 12 for each mouse. Histopathology of an arthritic joint reveals synovitis, pannus formation,

and cartilage and bone erosions. All mouse strains that are susceptible to CIA are high antibody responders to type II collagen, and there is a marked cellular response to CII.

5

EXAMPLE 9

SCW-induced monoarticular arthritis

Arthritis is induced as described by Schwab, *et al.*, *Infection and Immunity* 59:4436-4442 (1991)) with minor modifications. Rats receive 6 µg sonicated SCW [in 10 µl Dulbecco's PBS (DPBS)] by an intraarticular injection into the right tibiotalar joint on day 0. On day 21, the DTH is initiated with 100 µg of SCW (250 µl) administered i.v. For oral compound studies, compounds are suspended in vehicle (0.5% hydroxypropyl-methylcellulose/0.2% Tween 80), sonicated, and administered twice daily (10 ml/kg volume) beginning 1 hr prior to reactivation with SCW. Compounds are administered in amounts between 10 and 500 mg/kg body weight/day, such as 20, 30, 60, 100, 200, and 300 mg/kg/day. Edema measurements are obtained by determining the baseline volumes of the sensitized hindpaw before reactivation on day 21, and comparing them with volumes at subsequent time points such as day 22, 23, 24, and 25. Paw volume is determined by mercury plethysmography.

20

EXAMPLE 10

Mouse ear-heart transplant model

Fey, T.A. *et al.* describe methods for transplanting split-heart neonatal cardiac grafts into the ear pinna of mice and rats (*J. Pharm. and Toxic. Meth.* 39:9-17 (1998)). Compounds are dissolved in solutions containing combinations of absolute ethanol, 0.2% hydroxypropyl methylcellulose in water, propylene glycol, cremophor, and dextrose, or other solvent or suspending vehicle. Mice are dosed orally or intraperitoneally once, twice or three times daily from the day of transplant (day 0) through day 13 or until grafts have been rejected. Rats are dosed once, twice, or three times daily from day 0 through day 13. Each animal is anesthetized and an incision is made at the base of the recipient ear, cutting

30

- only the dorsal epidermis and dermis. The incision is spread open and down to the cartilage parallel to the head, and sufficiently wide to accommodate the appropriate tunneling for a rat or insertion tool for a mouse. A neonatal mouse or rat pup less than 60 hours old is anesthetized and cervically dislocated. The
- 5 heart is removed from the chest, rinsed with saline, bisected longitudinally with a scalpel, and rinsed with sterile saline. The donor heart fragment is placed into the preformed tunnel with the insertion tool and air or residual fluid is gently expressed from the tunnel with light pressure. No suturing, adhesive bonding, bandaging, or treatment with antibiotics is required.
- 10 Implants are examined at 10-20-fold magnification with a stereoscopic dissecting microscope without anesthesia. Recipients whose grafts are not visibly beating may be anesthetized and evaluated for the presence of electrical activity using Grass E-2 platinum subdermal pin microelectrodes placed either in the pinna or directly into the graft and a tachograph. Implants can be examined
- 15 1-4 times a day for 10, 20, 30 or more days. The ability of a test compound to ameliorate symptoms of transplant rejection can be compared with a control compound such as cyclosporine, tacrolimus, or orally-administered leflunomid .

EXAMPLE 11

20 Murine ovalbumin-induced eosinophilia

- Female C57BL/6 mice are obtained from the Jackson Laboratory (Bar Harbor, ME). All animals are given food and water ad libitum. Mice are sensitized with a single i.p. injection of OVA (grade V, Sigma Chemical Company, St. Louis, MO) adsorbed to alum, (10 µg OVA + 9 mg alum in 200 µl saline) or vehicle
- 25 control, (9 mg alum in 200 µl saline) on day 0. On day 14, the mice are challenged with a 12-minute inhalation of an aerosol consisting of 1.5% OVA (weight/volume) in saline produced by a nebulizer (small particle generator, model SPAG-2; ICN Pharmaceuticals, Costa Mesa, CA). Groups of eight mice
- 30 are dosed with oral vehicle (0.5% hydroxypropylmethylcellulose / 0.25% TWEEN-80), or a test compound at 10, 30, or 100 mg/kg in oral vehicle, 200 µl per mouse

p.o. Dosing is performed once per day starting on day 7 or day, and extending through day 16.

For determination of pulmonary eosinophilia, three days after the first OVA aerosol challenge (day 17), the mice are anesthetized with an i.p. injection of anesthetic (Ketamine/Acepromazine/Xylazine), and the tracheae is exposed and cannulated. The lungs and upper airways are lavaged twice with 0.5 ml of cold PBS. A portion (200 μ l) of the bronchoalveolar lavage (BAL) fluid is enumerated using a Coulter counter Model ZB1 (Coulter Electronics, Hialeah, FL). The remaining BAL fluid is then centrifuged at 300 x g for five minutes, and the cells are resuspended in 1 ml of HBSS (Gibco BRL) containing 0.5% fetal calf serum (HyClone) and 10 mM HEPES (Gibco BRL). The cell suspension is centrifuged in a cytopsin (Shandon Southern Instruments, Sewickley, PA) and stained by Diff Quick (American Scientific Products, McGraw Park, IL) to differentiate BAL leukocytes into neutrophil, eosinophil, monocyte or lymphocyte subsets. The number of eosinophils in the BAL fluid is determined by multiplying the percentage of eosinophils by the total cell count.

F. Other Embodiments

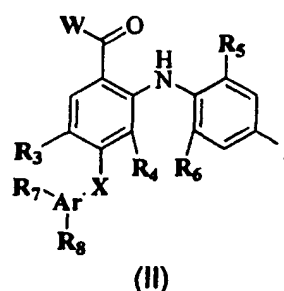
From the above disclosure and examples, and from the claims below, the essential features of the invention are readily apparent. The scope of the invention also encompasses various modifications and adaptations within the knowledge of a person of ordinary skill. Examples include a disclosed compound modified by addition or removal of a protecting group, or an ester, pharmaceutical salt, hydrate, acid, or amide of a disclosed compound. Publications cited herein are hereby incorporated by reference in their entirety.

What is claimed is:

CLAIMS

1. A compound having the formula (II):

5



W is OR₁, NR₂OR₁, NR_AR_B, NR₂NR_AR_B, or NR₂(CH₂)₂₋₄NR_AR_B;

- 10 R₁ is H, C₁₋₈ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, phenyl, (phenyl)C₁₋₄ alkyl, (phenyl)C₃₋₄ alkenyl, (phenyl)C₃₋₄ alkynyl, (C₃₋₈ cycloalkyl)-C₁₋₄ alkyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkenyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkynyl, C₃₋₈ heterocyclic radical, (C₃₋₈ heterocyclic radical)C₁₋₄ alkyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkenyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkynyl or (CH₂)₂₋₄NR_AR_B;

15

R₂ is H, phenyl, C₁₋₄ alkyl, C₃₋₄ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, or (C₃₋₈ cycloalkyl)-C₁₋₄ alkyl;

- 20 R_A is H, C₁₋₆ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, phenyl, (C₃₋₈ cycloalkyl)C₁₋₄ alkyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkenyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkynyl, C₃₋₈ heterocyclic radical, (C₃₋₈ heterocyclic radical)C₁₋₄ alkyl, (aminosulfonyl)phenyl, [(aminosulfonyl)phenyl]C₁₋₄ alkyl, (aminosulfonyl)C₁₋₆ alkyl, (aminosulfonyl)C₃₋₆ cycloalkyl, or [(aminosulfonyl)C₃₋₆ cycloalkyl]C₁₋₄ alkyl;

- 25 R_B is H, C₁₋₈ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, or C₆₋₈ aryl;

R_3 is halo, NO_2 , $\text{SO}_2\text{NR}_I(\text{CH}_2)_{2-4}\text{NR}_E\text{R}_F$, $\text{SO}_2\text{NR}_I\text{R}_K$ or $(\text{CO})\text{T}$;

T is C_{1-8} alkyl, C_{3-8} cycloalkyl, $(\text{NR}_E\text{R}_F)\text{C}_{1-4}$ alkyl, OR_F , $\text{NR}_I(\text{CH}_2)_{2-4}\text{NR}_E\text{R}_F$, or NR_ER_F ;

5

R_4 is H or F;

R_5 is H, methyl, halo, or NO_2 ;

10 R_6 is H, methyl, halo, or NO_2 ;

Ar is phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl;

each of R_7 and R_8 is independently selected from H, halo, C_{1-4} alkyl,
 15 $\text{SO}_2\text{NR}_J(\text{CH}_2)_{2-4}\text{NR}_G\text{R}_H$, $(\text{CO})(\text{CH}_2)_{2-4}\text{NR}_G\text{R}_H$, $(\text{CO})\text{NR}_J(\text{CH}_2)_{2-4}\text{NR}_G\text{R}_H$,
 $(\text{CO})\text{O}(\text{CH}_2)_{2-4}\text{NR}_G\text{R}_H$, $\text{SO}_2\text{NR}_G\text{R}_H$, and $(\text{CO})\text{NR}_G\text{R}_H$; provided that where Ar is a
 pyridyl, each of R_7 and R_8 is H;

each of R_C , R_D , R_E , R_F , R_G , and R_H is independently selected from H, C_{1-4} alkyl,
 20 C_{3-4} alkenyl, C_{3-4} alkynyl, C_{3-6} cycloalkyl, and phenyl; each of NR_CR_D , NR_ER_F ,
 and NR_GR_H can also be independently morpholinyl, piperazinyl, pyrrolidinyl, or
 piperadiny;

each of R_I and R_J is independently H, methyl, or ethyl;

25

R_K is C_{1-4} alkyl, C_{3-4} alkenyl, C_{3-4} alkynyl, C_{3-6} cycloalkyl, or phenyl;

X is O, S, or NH; and

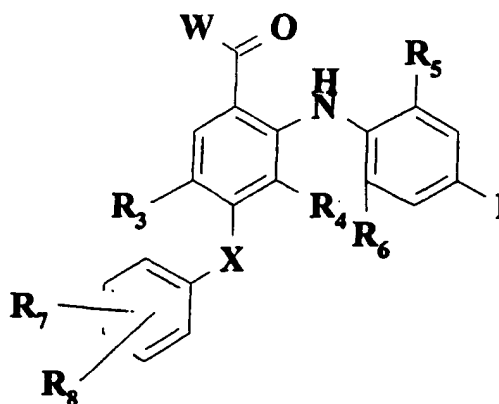
30 wherein each hydrocarbon radical or heterocyclic radical above is optionally
 substituted with between 1 and 3 substituents independently selected from halo,
 C_{1-4} alkyl,

C₃₋₆ cycloalkyl, C₂₋₄ alkyl, C₂₋₄ alkynyl, phenyl, hydroxyl, amino, (amino)sulfonyl, and NO₂, wherein each substituent alkyl, cycloalkyl, alkenyl, alkynyl or phenyl is in turn optionally substituted with between 1 and 2 substituents independently selected from halo, C₁₋₂ alkyl, hydroxyl, amino, and

5 NO₂;

or a pharmaceutically acceptable salt or C₁₋₇ ester thereof.

2. A compound of claim 1, having the following formula (I):



10

(I)

wherein

15 W is OR₁, NR₂OR₁, NR_AR_B, NR₂NR_AR_B, or NR₂(CH₂)₂₋₄NR_AR_B;

R₁ is H, C₁₋₈ alkyl, C₃₋₈ alkenyl, C₃₋₈ alkynyl, C₃₋₈ cycloalkyl, phenyl, (phenyl)C₁₋₄ alkyl, (phenyl)C₃₋₄ alkenyl, (phenyl)C₃₋₄ alkynyl, (C₃₋₈ cycloalkyl)-C₁₋₄ alkyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkenyl, (C₃₋₈ cycloalkyl)C₃₋₄ alkynyl, C₃₋₈

20 heterocyclic radical, (C₃₋₈ heterocyclic radical)C₁₋₄ alkyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkenyl, (C₃₋₈ heterocyclic radical)C₃₋₄ alkynyl or (CH₂)₂₋₄NR_AR_B;

R_2 is H, phenyl, C_{1-4} alkyl, C_{3-4} alkenyl, C_{3-8} alkynyl, C_{3-8} cycloalkyl, or $(C_{3-8}$ cycloalkyl)- C_{1-4} alkyl;

5 R_A is H, C_{1-6} alkyl, C_{3-8} alkenyl, C_{3-8} alkynyl, C_{3-8} cycloalkyl, phenyl, $(C_{3-8}$ cycloalkyl) C_{1-4} alkyl, $(C_{3-8}$ cycloalkyl) C_{3-4} alkenyl, $(C_{3-8}$ cycloalkyl) C_{3-4} alkynyl, C_{3-8} heterocyclic radical, $(C_{3-8}$ heterocyclic radical) C_{1-4} alkyl, (aminosulfonyl)phenyl, [(aminosulfonyl)phenyl] C_{1-4} alkyl, (aminosulfonyl) C_{1-6} alkyl, (aminosulfonyl) C_{3-6} cycloalkyl, or [(aminosulfonyl) C_{3-6} cycloalkyl] C_{1-4} alkyl;

10 R_8 is H, C_{1-8} alkyl, C_{3-8} alkenyl, C_{3-8} alkynyl, C_{3-8} cycloalkyl, or C_{6-8} aryl;

R_3 is halo, NO_2 , $SO_2NR_I(CH_2)_{2-4}NR_ER_F$, $SO_2NR_I R_K$ or $(CO)T$;

15 T is C_{1-8} alkyl, C_{3-8} cycloalkyl, $(NR_ER_F)C_{1-4}$ alkyl, OR_F , $NR_I(CH_2)_{2-4}NR_ER_F$, or NR_ER_F ;

R_4 is H or F;

20 R_5 is H, methyl, halo, or NO_2 ;

R_6 is H, methyl, halo, or NO_2 ;

25 each of R_7 and R_8 is independently selected from H, halo, C_{1-4} alkyl, $SO_2NR_J(CH_2)_{2-4}NR_GR_H$, $(CO)(CH_2)_{2-4}NR_GR_H$, $(CO)NR_J(CH_2)_{2-4}NR_GR_H$, $(CO)O(CH_2)_{2-4}NR_GR_H$, $SO_2NR_GR_H$, and $(CO)NR_GR_H$;

30 each of R_C , R_D , R_E , R_F , R_G , and R_H is independently selected from H, C_{1-4} alkyl, C_{3-4} alkenyl, C_{3-4} alkynyl, C_{3-6} cycloalkyl, and phenyl; each of NR_CR_D , NR_ER_F , and NR_GR_H can also be independently morpholinyl, piperazinyl, pyrrolidinyl, or piperadiny;

each of R_I and R_J is independently H, methyl, or ethyl;

R_K is C₁₋₄ alkyl, C₃₋₄ alkenyl, C₃₋₄ alkynyl, C₃₋₆ cycloalkyl, or phenyl;

X is O, S, or NH; and

5

wherein each hydrocarbon radical or heterocyclic radical above is optionally substituted with between 1 and 3 substituents independently selected from halo, C₁₋₄ alkyl, C₃₋₆ cycloalkyl, C₂₋₄ alkenyl, C₂₋₄ alkynyl, phenyl, hydroxyl, amino, (amino)sulfonyl, and NO₂, wherein each substituent alkyl, cycloalkyl, alkenyl, 10 alkynyl or phenyl is in turn optionally substituted with between 1 and 2 substituents independently selected from halo, C₁₋₂ alkyl, hydroxyl, amino, and NO₂;

or a pharmaceutically acceptable salt or C₁₋₇ ester thereof.

15

3. A compound of claim 1, wherein R₃ is NO₂.

4. A compound of claim 1, wherein R₄ is fluoro.

20 5. A compound of claim 1, wherein each of R₃ and R₄ is independently selected from H and fluoro.

6. A compound of claim 1, wherein R₅ is methyl, fluoro, or chloro.

25 7. A compound of claim 1, wherein R₆ is methyl, chloro, fluoro, nitro, or hydrogen.

8. A compound of claim 7, wherein R₆ is H.

30 9. A compound of claim 7, wherein R₆ is fluoro.

10. A compound of claim 1, wherein R_K is methyl or ethyl.

11. A compound of claim 1, wherein R_1 is H, methyl, ethyl, propyl, isopropyl, isobutyl, benzyl, phenyl, phenethyl, allyl, C_{2-5} alkenyl, C_{3-6} cycloalkyl, $(C_{3-5}$ cycloalkyl) C_{1-2} alkyl, $(C_{3-5}$ heterocyclic radical) C_{1-2} alkyl, or
 5 $(CH_2)_{2-4} NR_C R_D$.
12. A compound of claim 11, wherein R_1 is H or $(C_{3-4}$ cycloalkyl)- C_{1-2} alkyl.
- 10 13. A compound of claim 1, wherein R_2 is H or methyl.
14. A compound of claim 1, wherein R_A has at least one hydroxyl substituent.
- 15 15. A compound of claim 1, wherein R_A is H, methyl, ethyl, isobutyl, hydroxyethyl, phenyl, 2-piperidin-1-yl-ethyl, 2,3-dihydroxy-propyl, 3-[4-(2-hydroxyethyl)-piperazin-1-yl]-propyl, 2-pyrrolidin-1-yl-ethyl, or 2-diethylamino-ethyl; and R_B is H; or where R_B is methyl and R_A is phenyl.
- 20 16. A compound of claim 1, wherein W is $NR_A R_B$ or $NR_2 NR_A R_B$.
17. A compound of claim 1, wherein W is $NR_2 (CH_2)_{2-4} NR_A R_B$ or $O(CH_2)_{2-3} NR_A R_B$.
- 25 18. A compound of claim 1, wherein W is $NR_2 OR_1$.
19. A compound of claim 1, wherein W is OR_B .
20. A compound of claim 1, wherein R_7 is in the para position relative to
 30 X.
21. A compound of claim 20, wherein R_7 is iodo.

22. A compound of claim 1, wherein R₈ is in the ortho position relative to X.

5 23. A compound of claim 1 having the formula 2,4-bis-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-benzoic acid.

24. A compound of claim 1 selected from: 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-(4-sulfamoyl-phenylamino)-benzoic acid; 2-(2-
10 chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenylamino-benzoic acid; 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenoxy-benzoic acid; 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-phenylsulfanyl-benzoic acid; 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-4-(methyl-phenyl-amino)-5-nitro-benzoic acid;
15 benzamide, 2-[(2-chloro-4-iodophenyl)amino]-3-fluoro-N-hydroxy-4-[[4-[(2-hydroxyethyl)amino]-carbonyl]phenyl]amino]-5-nitro-; benzamide, 2-[(2-chloro-4-iodophenyl)amino]-4-[[4-[(dimethylamino)carbonyl]phenyl]amino]-3-fluoro-N-hydroxy-5-nitro-; 2-(2-chloro-4-iodo-phenylamino)-3,5-difluoro-4-phenylamino-benzoic acid; 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-nitro-4-(3-sulfamoyl-phenylamino)-benzoic acid; and 2-(2-chloro-4-iodo-phenylamino)-3-fluoro-5-
20 nitro-4-(2-sulfamoyl-phenylamino)-benzoic acid; and the corresponding hydroxamic acids and cyclopropylmethyl hydroxamates.

25. A pharmaceutical composition comprising a compound of claim 1 and a pharmaceutically-acceptable carrier.

25

26. A method for treating a proliferative disease, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

30

27. A method of claim 26, wherein said proliferative disease is selected from psoriasis, restenosis, autoimmune disease, and atherosclerosis.

28. A method for treating cancer, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

5

29. A method of claim 28, wherein said cancer is MEK-related.

30. A method of claim 28, wherein said cancer is breast, lung, ovarian, pancreatic, renal, or colorectal cancer.

10

31. A method for treating, or ameliorating the sequelae of, a stroke, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

15

32. A method for treating, or ameliorating the sequelae of, heart failure, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

20

33. A method for treating or reducing the symptoms of xenograft rejection, said method comprising administering to an organ transplant, limb transplant, skin transplant, cell(s) transplant, or bone marrow transplant patient a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

25

34. A method for treating osteoarthritis, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

30

35. A method for treating rheumatoid arthritis, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

5 36. A method for treating asthma, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

10 37. A method for treating cystic fibrosis, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

15 38. A method for treating hepatomegaly, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

20 39. A method for treating cardiomegaly, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

40. A method for treating Alzheimer's disease, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

25 41. A method for treating a complication of diabetes, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

30 42. A method for treating septic shock, said method comprising administering to a patient in need of such treatment a pharmaceutically-effective amount of a composition comprising a compound of claim 1.

43. A method for treating cancer, said method comprising (a)
administering to a patient in need of such treatment, a pharmaceutically-effective
amount of a composition comprising a compound of claim 1; and (b)
5 administering a therapy selected from radiation therapy and chemotherapy.

44. A method of claim 43, wherein said chemotherapy comprises a
mitotic inhibitor..

10 45. A method of claim 39, wherein said mitotic inhibitor is selected from
paclitaxel, docetaxel, vincristine, vinblastine, vinorelbine, and vinflunine.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/30418

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07C229/58 C07C321/30 C07D213/60 A61K31/10 A61K31/185
A61K31/21 A61K31/325 A61K31/44 A61P35/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07C C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
L, E	WO 99 01421 A (DOHERTY ANNETTE MARIAN ; BARRETT STEPHEN DOUGLAS (US); BRIDGES ALEX) 14 January 1999 (1999-01-14) claims 19-34; example 212	1-45
P, A	WO 99 01426 A (DOHERTY ANNETTE MARIAN ; BARRETT STEPHEN DOUGLAS (US); BRIDGES ALEX) 14 January 1999 (1999-01-14)	1-45
A	US 5 525 625 A (BRIDGES ALEXANDER J ET AL) 11 June 1996 (1996-06-11) cited in the application	1-45

☐ Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

S document member of the same patent family

Date of the actual completion of the international search

4 May 2000

Date of mailing of the international search report

15. 05. 00

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/30418

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Although claims 26-45 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REP

information on patent family members

Info. on Application No

PCT/US 99/30418

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